Optimization Study of Nitrate and Perchlorate Removal by Ion Exchange

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Abstract

The purpose of this study is to evaluate the ion exchange unit built by Krudico, Inc. for the removal of nitrate and perchlorate from ground water. The ground water at Site 300 is contaminated with volatile organic compounds (VOCs), nitrate and perchlorate. This ion exchange unit contains a nitrate specific resin. The resin is designed to preferentially remove nitrate from the ground water. The ion exchange unit will be connected to existing facilities at Site 300. During this study, a clean water flush of the ion exchange unit was performed and the unit was moved to Site 300. Determination of ideal operational parameters, minimization of process wastes and associated cost analyses are currently under evaluation.

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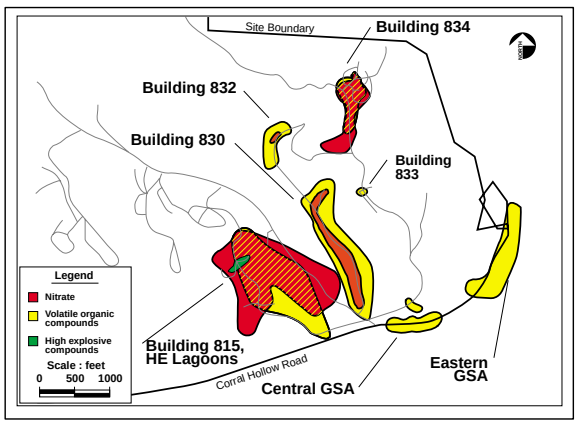
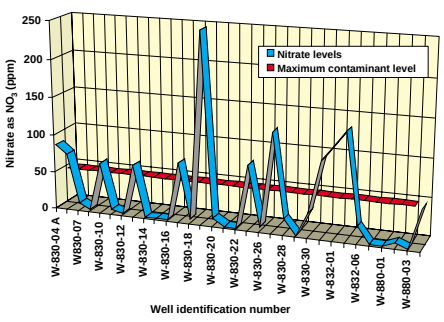
Problem Characterization

Site 300 is a US Department of Energy experimental test facility. High explosives were manufactured and tested at Site 300. As a result of these activities, contaminants were released to the local soil and groundwater. Primarily, volatile organic compounds (VOCs) contaminate the area, although nitrate, tritium, perchlorate, and high explosives have also been detected. There are no ongoing releases to the environment in this area. In 1990, the site was placed on the CERCLA National Priorities List and site-wide cleanup has been in effect since then.



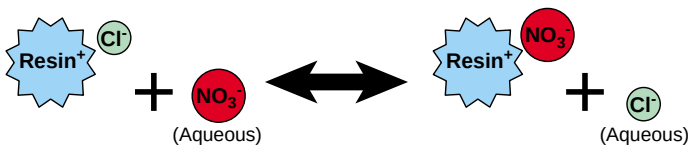
Peak nitrate concentrations of Site 300 wells prior to August 1997



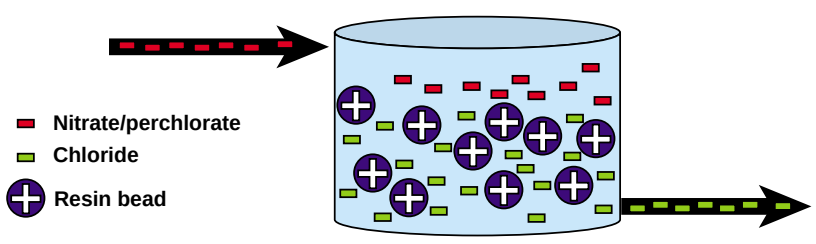
Approximately one third of the wells in the B-830 and B-832 areas have elevated concentrations of nitrate. The maximum contaminant level (MCL) for nitrate has been set at 45 parts per million (45 ppm). Concentrations up to 250 ppm have been measured at these wells. The action level for perchlorates has been set at 18 ppb. They have been detected up to 30 parts per billion (ppb). Several technologies are currently being considered to treat nitrate and perchlorate: phytoremediation, ion exchange and biological denitrification.

Mechanics of Ion Exchange

The ion exchange tanks are filled with resin beads. The resin bead consists of a styrene-divinylbenzene copolymer attached to a quaternary amine functional group. Before the resin is exposed to contaminated water, the functional group is bonded to a chloride ion.



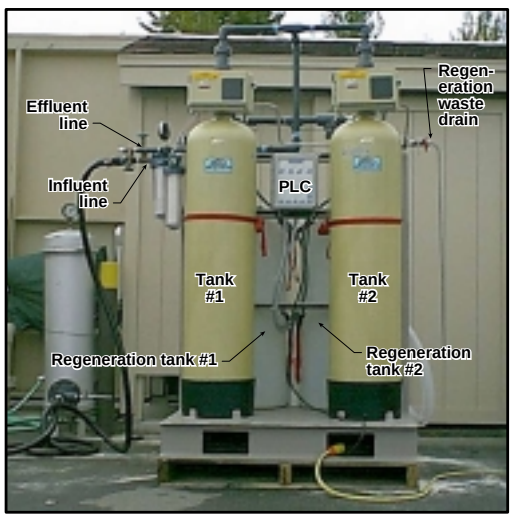
When contaminated water flows over the beads, the chloride ion is exchanged for a nitrate or perchlorate group, which has a higher affinity for the quaternary amine group. The chloride ion flows out with the effluent stream while the exchanged ion remains bonded to the functional group. When the resin is saturated with contaminant ions, it will be regenerated with a high concentration salt solution. The waste water is disposed of through the Hazardous Waste Division, the resin is then rinsed with clean water and returned to service.



Perchlorate Treatment

An experiment was conducted to determine if this method will be suitable for the removal of perchlorate. A three liter solution, of 27 ppb perchlorate contaminated water, was run through 45 in^3 of resin. The effluent concentration of perchlorate was non-detect.

Ion Exchange Unit



- **System can treat large volumes of contaminated water at a flow rate of 15 gpm.**
- **System can effectively reduce effluent nitrate concentration to below the MCL and perchlorates to below the action level.**
- **Programmable logic controller (PLC) automatically initiates regeneration cycle when a preset amount of water has flowed through system.**
- **Alternate regeneration of tanks allows system to be in continuous operation.**

The unit will be installed at Building 834 at Site 300. It will be connected to the current treatment facility. Ground water is pumped from nearby wells and sent through the treatment facility. The facility consists of a combination of filtration and air stripping (for removal of VOCs).

Typical well flow rates are about one to five gpm. The manufacturer's recommended flow rate is 15 gpm. Several hundred gallons of water will be collected. After the ground water has passed through the ion exchange unit, it will be discharged by air misting. The regeneration waste will be collected in a separate tank for later treatment.

Methods

Step 1: Clean Water Flush
a) Perform a pressure & leak test
b) Recirculate water to remove any contaminants
c) Familiarization of staff with the PLC and the operation of the unit

Step 2: Installation at Site 300, Building 834
a) Perform modifications to treatment facility
b) Set up equipment and connect to effluent lines
c) Perform activation procedure, collect initial performance data

Step 3: Optimization Studies
a) Achieve nitrate effluent concentrations below 45 ppm
b) Achieve perchlorate effluent concentrations below 18 ppb
c) Maximize time between regeneration cycles in order to reduce consumption of brine solution
d) Minimize amount of waste water produced by reducing regeneration cycle length
e) Minimize amount of salt required for regeneration solution
f) Determine cost per gallon of water treated
g) Calculate regeneration times for various influent nitrate/perchlorate concentrations

Current settings as suggested by vendor

Volume of water treated between regeneration cycles	4,000 gallons
Period of operation (between regeneration cycles) with 15 gpm flow rate	
Time required to collect sufficient amount of water at 1 gpm well flow rate	67 hours
Time required to collect sufficient amount of water at 5 gpm well flow rate	13 hours
Amount of waste solution produced	340 gallons
Salt solution percentage (w/v)	8 %

Summary

Ion exchange technology can effectively remove nitrate and perchlorate from Site 300 ground water. The ion exchange unit will produce significant volumes of waste that may limit its use to short term. Further work is required to evaluate regeneration cycles and minimization of waste produced.